WHY HAS FERTILITY FALLEN BELOW REPLACEMENT IN INDUSTRIAL NATIONS, AND WILL IT LAST?[†]

Population Growth, Dependency, and Consumption

By DAVID N. WEIL*

The possibility of declining population levels in the most developed countries has excited a good deal of comment of late. Is it an economic problem? To begin to answer such a question involves wrestling with a philosophical issue that has long discomforted economists: whether the appropriate social welfare function should take into account the total utility of people alive in future generations, or just their average utility. The former view may lead one to conclude that the best policy involves population growth to the point of impoverishment; the latter may lead one to look with equanimity upon the gradual disappearance of our population. (See Assaf Razin and Efraim Sadka [1995] for an extended discussion of this issue.)

In this paper I develop the implications of the latter of these two views, examining how population growth affects the average level of utility or, more specifically, consumption per capita. Further, I focus on only a single channel: the effect of population growth on the ratio of dependent consumers to working-age adults. Such a focus ignores at least two important considerations: first, the interaction of population growth with required investment, since new workers must be provided with capital (see David Cutler et al., 1990); second, the interaction between the size of the population and the availability of natural resources.

Despite leaving out many considerations, the focus on dependency mirrors popular discussion of the problem of population aging, which is the flip side of slower population growth. It has become a commonplace observation that the ratio of dependent elderly to working-age adults will rise over the coming decades in all of the developed countries, and that this rise in old-age dependency will mean lower consumption for one or both of these demographic groups. This observation would seem to imply that these low population growth rates are nonoptimal from the perspective of minimizing society's dependency burden. However, I show below that this is not necessarily true.

I. Population Growth and Dependency

I consider a very stylized model in which there are three demographic groups: working-age adults both produce and consume, while both the young and the elderly only consume. I assume that the wage per working age adult is 1, and that consumption is divided among members of different age groups in proportion to age-specific ''needs,'' which can be thought of as the relative prices of supporting members of each age group.[1]

Let Y_t, M_t, and O_t denote the fractions of the population that are young, working-age, and old at time t, and let p_Y and p_O denote the relative needs of the old and young, where the needs of working-age adults are set at 1. The level of consumption per capita (in working-age equivalents) is simply

$$C_t = \frac{M_t}{p_Y Y_t + M_t + p_O O_t}. \tag{1}$$

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[1] Obviously this structure ignores the different mechanisms (in particular, government, family, and savings) by which resources are transferred from workers to dependents (Weil, 1997).

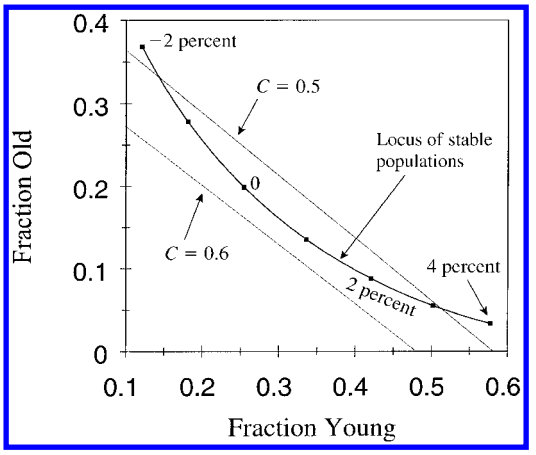

FIGURE 1. STABLE POPULATIONS AND ISO-CONSUMPTION LINES

Figure 1 shows a set of iso-consumption lines in the space of (Y, O). These are combinations of Y and O for which total needs-adjusted dependency (and thus, consumption) is constant. Lines closer to the origin represent higher levels of consumption, and the slope of the lines is given by the relative consumption needs of old and young people. For this illustration, I have taken young to be ages 0–19 and old to be age 65+, and I have used weights of $p_Y = 0.72$ and $p_O = 1.27$, which are constructed by Cutler et al. (1990) based on measures of health, education, and private consumption expenditures. Each iso-consumption line is labeled with a level of consumption relative to what could be consumed in a society in which there is no dependent population.

I now consider the effect of population growth on the level of consumption in society. I begin by examining stable populations, defined as those in which age-specific fertility and mortality rates have been constant for sufficiently long that the fraction of the population made up of people in each age group has stabilized. Figure 1 shows the locus of pairs of (Y, O) for stable populations. Points on the curve are labeled to show the corresponding rates of population growth.[2]

[2] Stable populations are constructed using estimated sex-specific mortality rates for the United States for the year 2000, and assuming zero immigration.

The population growth rate that maximizes consumption in a stable population (i.e., the golden-rule level of population growth) is given by the tangency of the stable population curve in Figure 1 with an iso-consumption line. For the dependency weights and mortality rate used in this illustration, the optimal rate of growth of population would be 0.7 percent per year, with corresponding young and old fractions of the population of 31 percent and 15 percent, respectively.[3] In the neighborhood of the optimal population growth rate, the effect of population growth on consumption in a stable population is fairly small. A stable population with a growth rate either 1 percentage point above or 1 percentage point below the optimum, for example, would have a level of consumption only 2.1-percent below that of an optimally growing population.

The level of dependency in the optimal stable population is not, however, the lowest level of dependency that can be achieved. Quite the contrary, along transition paths the level of dependency can depart significantly from that which is observed in a stable population. The intuition for this effect is simple: when the birth rate falls, the fraction of the population made up of children will fall right away; only much later will the other shoe drop, as the fraction of the population made up of dependent elderly rises. Figure 2 shows an example of such a transition: it consider a transition from a stable population with growth rate of 1.5 percent per year to one with a growth rate of zero, with the adjustment in fertility taking place over the course of 20 years. (The scale in the figure is magnified in comparison with Figure 1.) Points on the transition path are labeled to show the amount of time elapsed since the start of the fertility transition.

Figure 2 shows that consumption along the transition to lower population growth is significantly higher than it is in either the stable population at the beginning of the transition or

[3] My goal in this exercise is to illustrate the relation between population growth and consumption, rather than to calculate the exact optimal growth rate of population. A more thorough calculation would have to include a finer accounting of consumption needs and productivity by age, as well as adjustment for the capital needs of new workers.

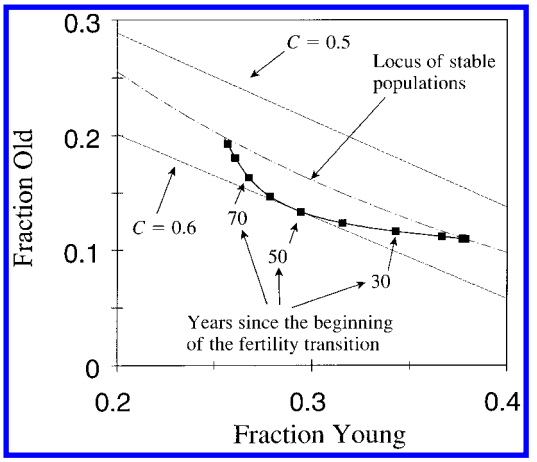

FIGURE 2. DEPENDENCY DYNAMICS AFTER A FALL IN FERTILITY

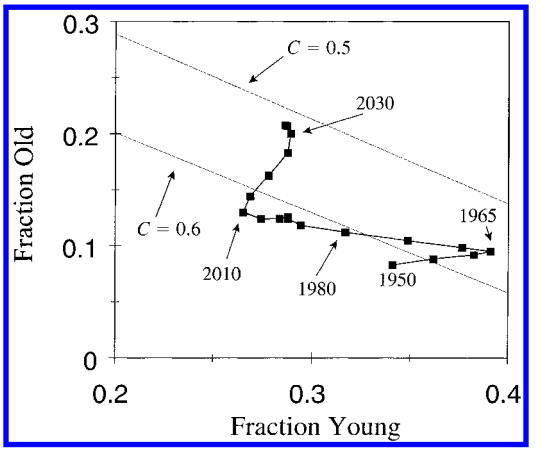

FIGURE 3. DEPENDENCY DYNAMICS IN THE UNITED STATES

the stable population at the end. In this case, consumption in the initial steady state is 1.4-percent below consumption at the optimum, and in the final steady state it is 1.0-percent below the optimum. But peak consumption along the transition (52 years after the start of the fertility transition) is 6.8-percent above consumption at the optimum. Obviously, transitions from low to high fertility entail a corresponding period of transitorily high dependency and low consumption. Moving between these same two steady states, in the other direction, the lowest level of consumption is 6.9-percent below consumption at the optimum.

The fact that transitions to lower population growth will always involve an initial period of lower-than-steady-state dependency, and thus unusually high consumption, delivers an interesting result: the modified golden-rule growth rate of population, defined as the growth rate of a stable population chosen by a social planner who discounts future utility (and who is concerned with the level of consumption per capita) will be lower than the growth rate of the population under the golden rule.[4]

[4] See W. Brian Arthur and Geoffrey McNicoll (1977) and Robert Willis (1980) for a much more detailed treatment of this issue.

II. Actual Paths of Dependency

Figure 3 shows the historical path of dependency for the U.S. population, as well as a forecast through 2040 (data are from United Nations Secretariat, 1996). In addition to the transitional dynamics due to changing fertility discussed above, the data here also reflect changes in mortality over time, as well as immigration. Nonetheless, the pattern of dependency changes associated with a transition to lower population growth that was seen in Figure 2 is clearly present in these data. Between 1965 and 1985, the effect of falling dependency was to raise consumption by 10.3 percent. Between 2010 and 2030, the effect of rising dependency will be to lower consumption by a total of 14.2 percent.

In the light of the last section's discussion, two points can be made. First, although an aging population will be raising the dependency burden in the next several decades, this does not mean that the population growth rate (and associated dependency burden) toward which the United States is moving is in any sense nonoptimal. Even if the population growth rate toward which the country is moving were the golden-rule rate, the final stage of the transition toward it would entail falling consumption. The second point is that if the new population growth rate is lower than optimal in terms of steady-state consumption, any

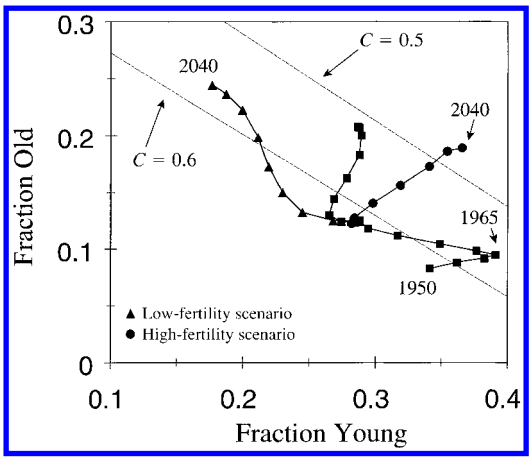

FIGURE 4. DEPENDENCY IN THE UNITED STATES UNDER ALTERNATIVE SCENARIOS

transition to a higher growth rate of population will necessarily involve a protracted period of higher-than-steady-state dependency, and correspondingly lower consumption.

Figure 4 shows the behavior of dependency in the United States under high- and low-fertility scenarios.[5] Over the next four decades, rising fertility simply makes the dependency problem worse, while declining fertility forestalls it. In 2040, consumption under the high-fertility scenario is 5.4-percent lower than under the medium forecast, while under the low-fertility scenario it is 5.9-percent higher than under the medium scenario.

III. A Simple Model

The derivation of optimal population growth rates presented above can be related to fertility and population growth in a particularly simple way, although at the cost of some realism. Assume that the three periods of life are equally long, and that there is no mortality until the end of old age. Define n_t as the ratio of Y_t to M_t, in other words, the fertility rate. Similarly, $n_{t-1} = M_t/O_t$. Equation (1) for consumption can be rewritten as

$$C_t = \frac{1}{p_Y n_t + 1 + p_O n_{t-1}^{-1}}. \tag{2}$$

This equation neatly captures the mechanism driving the results above: consumption is raised both by low fertility in the present period (which lowers the number of dependent children) and by high fertility in the past (which lowers the ratio of dependent elderly to workers).

The golden-rule level of fertility, which maximizes the consumption in the steady state, is

$$n^{GR} = \left(\frac{p_O}{p_Y}\right)^{1/2}. \tag{3}$$

Thus, if old people and young people have the same consumption needs, the optimal fertility rate will be 1, and the optimal population growth rate will be 0.

Assuming log utility and a discount rate of ρ, the modified golden-rule level of fertility is

$$n^{MGR} = \left(\frac{p_O}{p_Y(1+\rho)}\right)^{1/2}. \tag{4}$$

Solving the problem of a social planner who takes the initial ratio of old to working-age people (i.e., n_{t-1}) as given, it can be shown that fertility will converge toward the modified golden-rule level in an oscillatory fashion.

IV. Conclusion

Transitions to lower population growth entail a long period of reduced dependency, in which society benefits from lower spending on children while it has yet to pay for higher old-age dependency. Much of the increase in dependency over the next several decades simply represents the closing of this window. The level of dependency that will exist 30 years from now is not significantly different from that which would exist in an optimal stable population. Further,

[5] These scenarios are constructed by combining the low and high variant forecasts from the United Nations with the medium variant forecast that was used above. To create the low-fertility estimate for the year 2000, for example, I use the low variant forecast for the population group aged 0–4, and then the medium forecast for all other age groups. For the year 2005, I use the low variant for the population through age 9, and so forth. This procedure isolates the impact of differences in fertility forecasts, as opposed to differences in mortality or immigration.

any increase in fertility, which would lower old-age dependency in the long run, would entail a long period of higher-than-steady-state dependency. Put differently, even if the rate of population growth toward which the United States and other industrial nations are moving is lower than the optimum in terms of consumption per capita, any transition back to the optimal growth rate of population will entail a large transitory cost.

This discussion has ignored the question of *why* population growth is falling. One school of thought is that the dependency burden itself is responsible. An extreme version of this view is presented by Peter Drucker (1997 p. 20): ''The developed world is in the process of committing collective suicide. Its citizens are not having enough babies to reproduce themselves, and the cause is quite clear: its younger people are no longer able to bear the increasing burden of supporting a growing population of older, nonworking people.'' As Section II makes clear, however, the major burden of old-age dependency has yet to be felt. Thus, unless people today are extremely forward-looking, Drucker's analysis suggests that the dependency-induced reduction in fertility has only just begun.

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